AUSTRIAN (EUROPEAN BLACK) PINE IN EASTERN NEBRASKA: A Provenance Study

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USDA Forest Service
Research Paper RM-180
November 1976

Rocky Mountain Forest and
Range Experiment Station
Forest Service
U.S. Department of Agriculture
Fort Collins, Colorado 80521

Read, Ralph A.
1976. Austrian (European black) pine in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-180, 8 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Heights, growth rates, flowering, cone production, needle dimensions, and resistance to Dothistroma needle blight differed significantly among 25 rangewide origins in a 12-year test. The fastest growing origin, also of highest resistance to Dothistroma needle blight, was from Yugoslavia; this origin is recommended for eastern Nebraska. Several origins grew slowly or died because of winter injury. Most origins were moderately to extremely susceptible to *Dothistroma pini.*

Keywords: *Pinus nigra, Dothistroma pini,* provenances, growth, needles, disease resistance, windbreaks.

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[1]Central headquarters maintained at Fort Collins, in cooperation with Colorado State University; research reported here was conducted at the Station's Research Work Unit at Lincoln, in cooperation with the University of Nebraska.

Preface

This provenance study is one of a dozen experimental plantations of various tree species established on the Horning State Farm near Plattsmouth, Nebraska, which is administered by the Department of Forestry of the University of Nebraska. The USDA Forest Service, through its Rocky Mountain Forest and Range Experiment Station Research Work Unit at Lincoln, cooperates with the Nebraska Agricultural Experiment Station in research conducted on this experimental area.

The specific purpose of this work is to find and develop better adapted trees for use in all kinds of plantings, environmental and commercial, throughout Nebraska and the Central Plains. Such provenance studies of different species provide plants of known origin for evaluation of adaptability, and genetic variation, and for selection, propagation, and breeding for resistance to disease and insect pests. Studies have been reported in publications listed below.

The diversity of tree planting materials under study at this and many other locations in the Plains was made possible through cooperation in a Regional Tree Improvement Project (NC-99, formerly NC-51) of the North Central States Agricultural Experiment Stations.

Credits are due Jonathan W. Wright, Professor of Forestry, Michigan State University, for initiating the Regional study and providing the planting stock, and to Walter T. Bagley, Associate Professor of Forestry, University of Nebraska, for cooperation in planting and maintenance of the plantations.

Published Reports on Provenance Studies

Published Reports on Provenance Studies

1971. Scots pine in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-78, 13 p. by Ralph A. Read.

1975. Jack pine provenance study in eastern Nebraska. USDA For. Serv. Res. Pap. RM-143, 8 p. by John Sprackling and Ralph A. Read.

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1976. Austrian (European black) pine in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-180, 8 p. by Ralph A. Read.

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AUSTRIAN (EUROPEAN BLACK) PINE IN EASTERN NEBRASKA: A Provenance Study

Ralph A. Read

Austrian pine (*Pinus nigra* Arnold) was one of the early tree introductions into the United States (Wright and Bull 1962), and is now one of the most common foreign ornamentals in this country (Little 1961). It was used successfully in the Prairie States Forestry Project (The Plains Shelterbelt) in Nebraska, Kansas, and Oklahoma, chiefly because it is not susceptible to terminal damage by tipmoth, as is ponderosa pine (Read 1958). Austrian pine grows well throughout a broad range of soils including sandy loams and silty clays, and appears well adapted to calcareous soils. It is hardy in southern New England, the north central United States, and in parts of the West.

The natural range of *P. nigra* extends from longitude 5° west in Spain and Morocco to about 40° east in eastern Turkey, and from 35° north latitude in Morocco and Cyprus to 48° in northeastern Austria, and to 45° in the Crimea, USSR (fig. 1). Rangewide, the species has a rather discontinuous and patchy distribution on the islands and peninsulas of the Mediterranean, and in the mountains to the north. The largest contiguous areas are in eastern Spain, throughout the Balkans, and in western Turkey (Critchfield and Little 1966).

The most common seed source of *P. nigra* introduced and planted in the United States was apparently variety *austriaca* (Hoess) Aschers. and

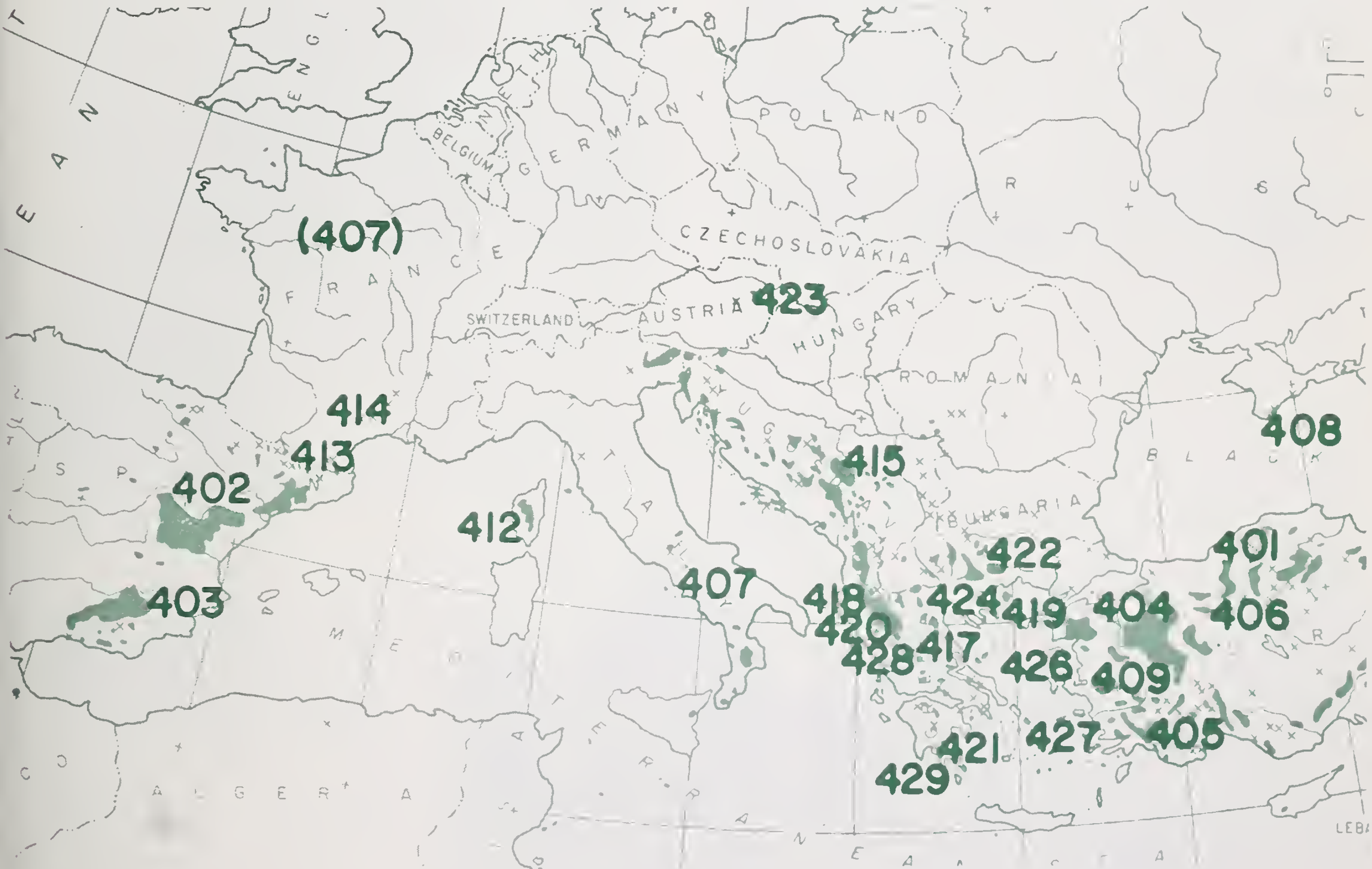

Figure 1.—Natural range of *Pinus nigra* (Critchfield and Little 1966), and location of provenances in the eastern Nebraska plantation.

Graebn. Sources from other parts of the natural range are relatively unknown in this country, except in a few arboreta (Wright and Bull 1962). Even in Europe the seed sources favored for planting were from a limited number of regions such as Austria, Calabria (southern Italy), and Corsica. Since these regions are mostly peripheral to the main forest distribution of the species, there is a good possibility that the major regions may prove of greater value as seed sources (Debazac 1971).

Austrian pine has been grown in farm windbreaks and as a roadside tree in the eastern Plains for at least 90 years. It was one of the most extensively planted pine trees in eastern Nebraska, according to Tillotson (1906). It was one of the first conifers tested for adaptability in the 1891 Bruner plantation in the Nebraska sandhills, and was planted on quite a few acres as early as 1909 in the sandhills of the Nebraska National Forest (Pool 1953).

There is no reliable method of determining which origins of *P. nigra* now survive in the older plantings of the eastern Plains, but the probability is great that planting stock was obtained from nurseries in the eastern United States, whose seed supplies were predominantly of the *austriaca* variety. Fairly large variations in form, branching, length and stiffness of needles, growth rate, and susceptibility to needle blight are distinctly evident in local plantings.

A cooperative Regional Tree Improvement Project (NC-99) of the North Central States Agricultural Experiment Stations made it possible to test, for the first time, a wide range of *Pinus nigra* origins for adaptability and growth in Nebraska. This paper reports the results of that field study 12 years after it was established in 1962 in eastern Nebraska (fig. 2).

Previous Work

A comprehensive summary of research in the genetics of *Pinus nigra* is now available in a monograph by Vidakovic (1974). Most past research describing genetic variation in the species has been conducted in Europe by Delevoy (1949, 1950), Fukarek (1958), Vidakovic (1960), Debazac (1971), and by others reviewed in the following paragraphs.

Rőhrig (1957, 1966, 1969) described selected natural stands throughout parts of the range from Spain to Turkey, and reported results of a provenance study including variation in seed characteristics, and plantation performance at four locations in West Germany. Bassiotis (1967) studied needle, shoot, bud, cone, and seed characters of 23 natural stands in Greece. Significant differences were found between southeast and northwest provenances. The Greek populations, although similar to var. *austriaca* in some trees, and to var. *pallasiana* in others, were considered distinct from other races of European black pine.

Arbez and Millier (1971) reported a study of needle morphology which included sources from Spain, France, Corsica, Italy, Bulgaria, Turkey, and Crimea, but not from Greece and Yugoslavia. Significant differences in needle length and curvature, and in number of serrations and stoma rows on needles, were used to classify the sources into

Figure 2.—General view of the Austrian pine provenance plantation. Trees were planted in 1962; many origins are over 20 feet tall after 14 years. The marker is 12 feet tall against origin 404 from northwest Turkey.

geographic groups. Origins from Spain and southern France were similar, and distinct from all other geographic areas. Corsican origins were clearly distinct from Calabrian (Italy). Origins from Turkey, Bulgaria, and Crimea were similar, and generally distinct from those in the western range.

In the United States, performance of Austrian and Corsican pines in 40-year-old arboretum plots in Ohio was reported by Aughanbaugh et al. (1958).

Wright and Bull (1962) reported results of a replicated test of 2-year-old seedlings of 29 range-wide origins, with Greek locations predominating. Corsican origins were distinct from all others, and were recognized as var. *poiretiana*. The other 26 origins appeared to fall into two groups: (1) Spain, France, Austria, Turkey, and Crimea, and (2) Yugoslavia and Greece. They concluded that the variation pattern among progenies from all origins, except those from France and Corsica, was nonsystematic, and that the isolation of small discontinuous populations, which typifies the natural distribution of *P. nigra*, has been an effective selection pressure in causing differentiation and genetic drift.

Seedlings from the above study were field planted at various locations in central United States. Although performance of four of those plantations, including the Nebraska, was reported by Wheeler et al. (1976), this Paper presents the Nebraska data in greater detail. These same materials were also the basis for Lee's (1968) article on needle characteristics and 5-year performance in a Michigan provenance test. He described five distinct groups which were considered equivalent to varieties as follows: (1) Spanish-French (var. *pyrenaica* and var. *cebennensis*), (2) Corsican (var. *poiretiana*), (3) Austrian (var. *austriaca*), (4) Yugoslav-Greek-Turkish (var. 'Balkan'), and (5) Crimea (var. *caramanica*). Lee's data on growth performance and needle characteristics will be compared with our data in the results that follow.

Materials and Methods

Seedlings of 25 origins (table 1, fig. 1) under study by Michigan State University, Department of Forestry (Lee 1968, Wright and Bull 1962) were field planted in eastern Nebraska in 1962. Two-year-old seedlings were shipped to Nebraska by air freight in 1961 from the Michigan nursery, and were grown for one additional year in the Forest Service Bessey Nursery in central Nebraska before being field planted.

The 2+1 transplant stock was machine planted in April 1962 on previously disked land. A 20-inch-wide (0.5 m) band on both sides of each tree row was sprayed with Simazine 80W at 4 pounds per acre after planting to control weeds. Plantation failures were replaced during the first two seasons with extra stock lined out nearby. Since all trees of origins 413, 414, and 429 died the first year, these plots were replanted with excess lineout stock of origins 406, 417, 419, and 423; thus the number of trees of those origins in table 2 is greater than 20.

Table 1.--Austrian pine tested in an eastern Nebraska field plantation, with seed origin location data arranged geographically (see fig. 1)

Michigan State Univ. origin No.	Country and location where seed originated		Latitude	Longitude[1]	Elevation	
			°N	*°E*	*ft*	*m*
403	SPAIN	Segura Mtn	37.9	3.0W	3700	1130
402	SPAIN	Valdemaca Mtn	40.2	1.8W	3400	1040
413	FRANCE	Pyrennes-Orientales	42.5	2.3	2300	700
414	FRANCE	Herault	43.8	3.5	2000	610
412	FRANCE	Corsica	42.0	9.2	3000	910
407	FRANCE[2]	Arb. des Barres	47.8	2.7	500	150
423	AUSTRIA	Vienna	48.2	16.2	1600	490
415	YUGOSLAVIA	Tara Plateau	43.9	19.5	4000	1220
417	N GREECE	Pieria Mtn	40.3	22.3	4900	1490
418	N GREECE	Pindos Mtn	40.1	21.3	4300	1310
420	N GREECE	Zygos Mtn	39.8	21.0	4600	1400
428	N GREECE	Pindos Mtn	39.5	21.2	4000	1220
421	S GREECE	Mt. Parnon	37.2	22.6	4300	1310
429	S GREECE	Mt. Parnon	37.0	22.2	5000	1520
424	NE GREECE	Dadia	41.1	23.4	700	210
422	NE GREECE	Boz Dagh Mtn	41.3	23.9	2800	850
419	NE GREECE	Thasos Island	40.7	24.7	3300	1000
426	E GREECE	Lesbos Island	39.2	26.5	2300	700
404	NW TURKEY	Dursunbey	39.4	28.2	2800	850
409	NW TURKEY	Dursunbey	39.4	28.2	2800	850
427	E GREECE	Samos Island	37.6	26.8	2900	880
405	SW TURKEY	Goktepe Mtn	37.2	28.5	3200	980
401	N TURKEY	Ankara	40.5	32.7	4000	1220
406	N TURKEY	Ankara	40.5	32.7	4300	1310
408	U.S.S.R.	Crimea	46.0	34.0	1650	500

[1]All East, except as noted.
[2]Presumed Italian (Calabrian) origin collected in France plantation, and noted as ITA in tables 2 and 3.

The provenance plantation is located 20 miles south of Omaha, near Plattsmouth, Nebraska, on the Horning State Farm experimental area managed by the Department of Forestry, University of Nebraska. This location, at 96° west longitude and 41° north latitude, is the same latitude as the mid-range of the natural distribution of *Pinus nigra*. The site is near the top of a gentle southeast-facing slope of silt loam soil derived from loess, which has been cultivated for a number of years in row crops. The layout consists of 10 tree rows, 370 feet long, on the contour. There are five replications of two rows, with 25 randomly located four-tree plots in each replication. Trees are 7 feet (2.1 m) apart, in rows 14 feet (4.2 m) apart.

Maintenance through the first 6 years consisted of weed control with Simazine along the tree rows and mowing between rows. Mowing was continued for several years, until the tree crowns closed. All trees in several plots were damaged during the first 3 years by mouse girdling, and most of these eventually died and were removed. Strychnine-treated grain was then used to control rodents, and they caused no further damage.

Tree heights were measured at the end of growing seasons from 1963 through 1973, except 1970 and 1972. Each tree was evaluated for degree of infection by *Dothistroma pini* in March 1968 and February 1970 (Peterson and Read 1971) and again in March 1974. Occurrence of flowering was recorded in May 1970, and cone production was rated in 1973. Needle fascicles not infected by *Dothistroma pini* were sampled in fall 1973 from current-year shoots for length and diameter measurements.

Dothistroma needle blight was so severe by 1969 throughout the plantation that we decided to reduce its effect by control measures. Spraying the lower 6 to 8 feet (1.8 to 2.4 m) of each tree with Bordeaux mixture in May 1970 reduced the severity of the disease for at least 2 years. The disease has continued to increase since 1973, however, and once again is severe throughout the plantation.

Considerable crowding of trees within each row was evident by February 1972, at which time we pruned lower branches from alternate trees to half their total height to relieve some of this competition. Height growth during the 2 succeeding years (1972, 1973) was not significantly affected by the pruning. Therefore all remaining trees were pruned up to 6 feet (1.8 m) in November 1974, to provide better access for cone collection equipment and for field tour observations.

Results

Survival

An initial survival averaging 75 percent or better has been sustained for most origins throughout 12 years (table 2); 13 of the 25 origins survived 90 percent or better. We attribute this high survival to the use of transplant stock (2+1), which had one extra year in the nursery to develop better top-root balance. Several other studies of these same materials planted as 2+0 stock in the North Central region were near failures.

All trees of origins 413 and 414 (southern France), and 429 (southern Greece) died of winter injury during the first 2 years after planting. Corsican origin 412, although showing considerable needle mortality each year, has survived but grown slowly. Greek origins 421 (south) and 422 (north) also had greater than average mortality. Approximately 20 percent of the total mortality of 135 trees was caused by mouse girdling.

Height Growth

Yugoslavian origin 415, reported by Peterson and Read (1971) as consistently high in resistance to *Dothistroma pini*, exceeded other origins in height growth (table 2). Nine other origins were also considerably above average. Four northern Greece origins—417, 418 (fig. 3), 420, and 428 located in the Pindos Mountains at southern end of the Dinaric Alps, which parallel the Adriatic Coast of Yugoslavia and Albania—were in this group. Origin 407 from Italy by way of a French plantation, origin 408 from the Crimea, 409 from Turkey, and 427 from Samos Island off the southwest coast of Turkey, were also in this faster growing group. It should be noted that two of these fast growing origins, 408 from the Crimea and 427 from Samos Island, are separated by over 8° of latitude.

In the average and slower groups were origin 423 from Austria, four origins from Turkey (401, 406, 404, and 405), Greek island origins Thasos and Lesbos (419 and 426), and Spanish origins (402 and 403). The slowest origins were from Corsica (412), southern Greece (421), and northern Greece (424).

Height growth rate was slow but steady during the first 3 years after planting. The mean annual height growth since 1966 has been 1.80 feet (table 2, fig. 4). Most origins have shown a steady, consistent growth rate, but the three slowest growers, though increasing during 1967-71, have since fallen off.

Height growth data compare reasonably well with Lee's (1968) results in Michigan. In a 5-year-old plantation of the same materials as in our study, he reported the Crimean origin 408 fastest growing, followed by the Yugoslavian origin 415. His Austrian origin 423 grew slowly, and Corsican 412 was the slowest.

Our results also corroborate in several ways Röhrig's (1957, 1966) assessment of growth in parent stands and performance in his provenance study in West Germany. He reported that the best parent stands in the territory from the eastern Alps to southern Greece were those in central Yugoslavia. In his 6-year-old provenance study, however, the origin of best growth was from southern Italy, which would be comparable to our second-ranked origin 407. His Yugoslavian, northern Greece, and Austrian origins performed about the same, but were considerably slower than the Calabrian (southern Italy). Although he assessed the Spanish and Corsican parent stands as very good, most of those origins did not perform satisfactorily in his provenance study because they suffered winter injury. Although our Corsican origin was similarly affected, our Span-

Table 2.--Austrian pine tested in an eastern Nebraska field plantation, with seed origin, survival records, and other characteristics (origins arrayed in order of growth rate)

Michigan State Univ. origin No.	Basis: Total trees	Survival	Height growth: Mean annual 1966-73	Height growth: 12-yr total	Height growth: Plantation mean	Flowering characteristics: 1969: 8-yr-old trees with-- staminate strobili	Flowering characteristics: 1969: 8-yr-old trees with-- ovulate strobili	Flowering characteristics: 1973: 12-year-old trees with >10 cones	Needle length: Average	Needle length: Plantation mean	Fascicle diameter: Average	Fascicle diameter: Plantation mean	Extremes
	No.	*%*	*ft*	*ft*	*%*	*%*	*%*	*%*	*mm*	*%*	*mm*	*%*	
YUG 415	15	90	2.00	19.4	113	7	27	29	129	95	1.67	101	
ITA 407	18	100	1.98	18.8	109	25	50	90	149	110	1.66	101	
SSR 408	17	85	1.95	18.6	108	35	30	45	152	112	1.80	109	Long, thick
TUR 409	17	90	1.91	18.6	108	56	61	43	146	107	1.72	104	
GRE 418	17	95	1.89	18.5	108	31	31	50	139	102	1.70	103	
GRE 420	20	100	1.94	18.4	107	0	10	15	121	89	1.56	95	
GRE 422	4	20	1.98	18.4	107	25	0	0	114	84	1.76	107	Short, thick
GRE 427	16	80	1.96	18.3	106	6	0	29	148	109	1.70	103	
GRE 417	38	100	1.91	18.1	105	32	41	50	130	96	1.59	96	
GRE 428	20	100	1.86	18.0	105	15	50	45	127	93	1.55	94	
AUS 423	39	100	1.84	17.7	103	23	73	80	132	97	1.77	107	
GRE 419	33	95	1.86	17.6	102	18	14	10	125	92	1.54	93	
TUR 406	32	90	1.86	17.4	101	15	37	63	140	103	1.73	105	
TUR 401	18	90	1.76	17.0	99	6	67	78	135	99	1.79	108	
SPA 402	16	95	1.75	16.8	98	10	21	50	163	120	1.44	87	Long, slender
TUR 404	16	80	1.79	16.7	97	44	50	43	131	96	1.66	101	
TUR 405	16	80	1.71	16.5	96	12	12	14	133	98	1.74	105	
GRE 426	18	95	1.63	15.8	92	37	37	30	128	94	1.74	105	
SPA 403	15	75	1.61	15.2	88	7	20	0	157	115	1.30	79	Long, slender
COR 412	12	60	1.70	14.8	86	0	0	0	151	111	1.59	96	Long, curved
GRE 421	12	60	1.56	14.4	84	0	0	30	111	82	1.63	99	Short
GRE 424	14	70	1.43	14.1	82	21	28	50	126	93	1.84	112	Short, thick
GRE 429		0											
FRA 413		0											
FRA 414		0											
Plantation means		73	1.80	17.3	100				136	100	1.65	100	

Figure 3.—Height growth of origin 418 northern Greece (left) considerably exceeds that of origin 412 Corsica (right). The northern Greece source shown here is very similar to the Yugoslavian source, which has shown resistance to Dothistroma needle blight.

ish sources have not yet been hurt by winter cold, but they have shown extreme susceptibility to *Dothistroma pini* (Peterson and Read 1971).

Flowering

No relationship between flowering and rate of growth or geographic location of origins could be detected (table 2). Prior to 1969 the plantation produced no staminate and only a few ovulate strobili. Since 1969 the percentage of trees bearing ovulate strobili has increased sharply.

The fast-growing, Dothistroma-resistant, Yugoslavian origin 415 does not rate high in flowering. The most prolific origins to date have been Italian 407, Austrian 423, and two Turkish origins 401 and 406. Of these, only 407 is in the fast-growth class. Several origins have not produced cones.

Although *Pinus nigra* tends to flower and produce many cones each year in eastern Nebraska, it does not necessarily follow that viable seed set is obtained annually. Data on flowering, frequency and size of cone crops, and seed set are not likely to be reliable until the plantation is 20 or more years old.

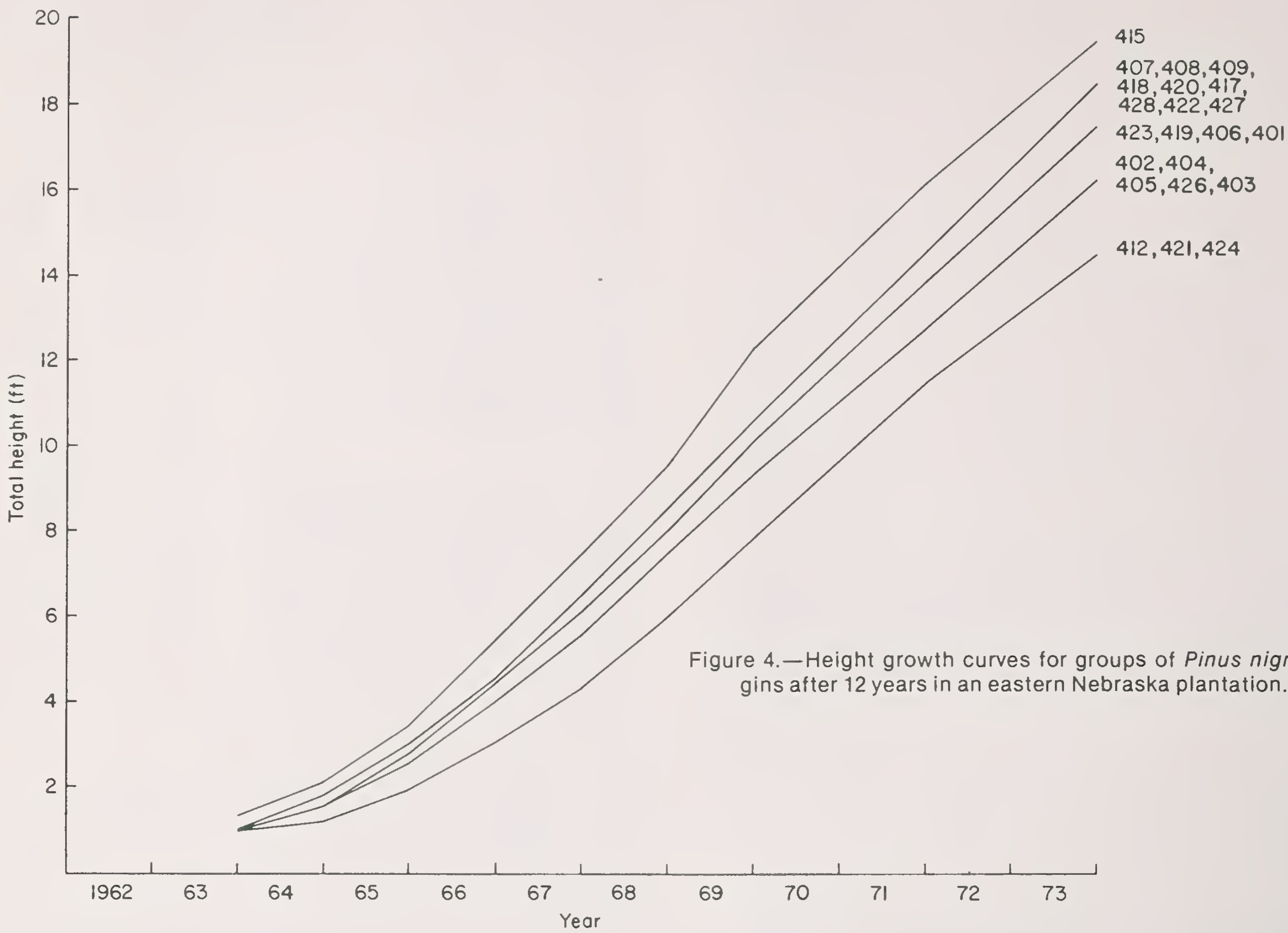

Figure 4.—Height growth curves for groups of *Pinus nigra* origins after 12 years in an eastern Nebraska plantation.

Needle Characteristics

Differences in needle lengths and fascicle diameters among origins were significant. Average length of needles for all origins in the plantation was 136 mm; average fascicle diameter was 1.65 mm (table 2). The two Spanish origins, 402 and 403, had the longest and most slender needles. In contrast, two Greek origins, 422 and 424, had short, thick needles. Most Greek origins had shorter needles than the average, except Samos Island origin 427 off the southwest coast of Turkey.

Needles of trees from Corsica origin 412, Crimea 408, and Italy 407 were also very long, but were different in fascicle diameter or curvature. Corsican trees had long, curly needles, Crimean trees had long, very thick needles, while Italian trees had needles that were long, but of average thickness.

Our data agree relatively well with needle measurements of the same sources in Michigan reported by Lee (1968). His needle lengths and widths averaged 70 to 80 percent of ours, which may be explained by the fact that his materials were only 5 years old and growing in a colder environment with a shorter growing season.

Other studies on needle lengths are not easy to compare with ours, because they either do not contain rangewide sources or they are of different age trees. Despite this difficulty, our data agree with the extremes reported on needle lengths. Arbez and Millier (1971) for example, reported data for 3-year-old seedlings from origins similar to ours, except for Greece, Yugoslavia, and Austria. Their Spanish, Corsican, and Crimean origins had the longest needles, and those of all 10 Corsican origins sampled were very curly. Bassiotis (1967), reporting needle lengths for 18 natural stands in Greece, found northeastern and extreme southern stands had the shortest needles. This was also the case with our origins 422, 424, and 421, which were comparable to his locations. Bassiotis' Thasos Island and Samos Island stands had long needles, whereas only trees of our Samos Island origin 427 were long needled.

Abnormalities in needle structure of *P. nigra* were reported by Lee and Andresen (1968). We encountered two trees, one of origin 417 and one of 428, both in northern Greece, which contained three-needle fascicles. This variation from the normal will be followed in greater detail during subsequent sampling, to determine its frequency on individual trees as well as throughout the different origins.

Infection by Dothistroma

Although the fastest growing origin (415 from Yugoslavia) was least infected by *Dothistroma pini*, relative resistance has little relationship overall with rate of growth (table 3). Austrian origin 423 and two northern Greece origins, 418 and 420, which are at the southern end of the same mountain range as the Yugoslavian source, appeared to be somewhat resistant. The slowest growing origin, 424 from northeastern Greece, showed little resistance but was less susceptible than the Spanish (fig. 5) and Turkish origins. This corroborates the observation of Peterson and Read (1971) that a broad range of genetic material (in growth rate and other characters) is available for selection and breeding for resistance.

Table 3.--Austrian pine origins in an eastern Nebraska plantation, and their record of infection by *Dothistroma pini* in 1968 (Peterson and Read 1971)

Michigan State Univ. origin No.	1968 new needles		1967 (2d yr) needles	New and 2d yr needles	Origins least infested
	Needles infected	Trees infected	Needles infected	Trees infected	
	%	%	%	%	
YUG 415	0	0	6	65	x
ITA 407	6	35	89	95	
SSR 408	22	53	80	94	
TUR 409	13	50	75	95	
GRE 418	1	26	44	84	x
GRE 420	9	50	53	75	x
GRE 422	--	--	--	--	
GRE 427	28	62	94	100	
GRE 417	5	45	55	95	
GRE 428	22	70	88	100	
AUS 423	4	35	23	65	x
GRE 419	16	50	79	83	
TUR 406	35	76	84	94	
TUR 401	26	52	71	89	
SPA 402	53	79	98	100	
TUR 404	28	62	87	88	
TUR 405	19	62	79	94	
GRE 426	36	68	93	95	
SPA 403	75	95	100	100	
COR 412	75	83	90	92	
GRE 421	96	100	100	100	
GRE 424	11	43	51	79	x
Plantation means	28	57	73	90	

Figure 5.—Although Spanish source 402 shown here is moderately fast growing, it has long, slender needles highly susceptible to Dothistroma needle blight. In contrast, the taller tree in the background from Yugoslavia has shorter, thicker, and darker needles resistant to the needle blight.

Interesting new data on monoterpene analyses are available from Arbez et al. (1974). Utilizing new source materials not reported in previous research (but with no Greek origins), they found highly significant differences in limonene composition between Corsican and Italian origins. Corsican origins also had traces of terpinolene and Δ 3-carene, which no other sources contained.

Most interesting, however, is the high content of β-pinene in both Yugoslavian origins sampled. Two other origins, one from Turkey and the other from Crimea, were also high in β-pinene, but these two did not rate high in Dothistroma resistance in our plantation. Only the Spanish origins were significantly higher in myrcene content than any other origin, and these were among the most susceptible to Dothistroma in our plantation.

Discussion

Overall performance of the 25 origins of *Pinus nigra* in this eastern Nebraska plantation indicates superiority of the central Yugoslavian origin 415. Two other origins, 418 and 420 from the Pindos Mountains in northern Greece, also show promise as reasonably fast growers with "some" resistance to Dothistroma needle blight. Austrian origin 423 also rates fairly high in Dothistroma resistance, but height growth is not as fast as 10 other origins.

We recommend the Yugoslavian seed source for planting stock production in Nebraska. Seedlings of this origin are being produced for Clarke-McNary tree distribution, and addition, a seed orchard of Yugoslavian seedling transplants has been established.

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Heights, growth rates, flowering, cone production, needle dimensions, and resistance to Dothistroma needle blight differed significantly among 25 rangewide origins in a 12-year test. The fastest growing origin, also of highest resistance to Dothistroma needle blight, was from Yugoslavia; this origin is recommended for eastern Nebraska. Several origins grew slowly or died because of winter injury. Most origins were moderately to extremely susceptible to *Dothistroma pini.*

Keywords: *Pinus nigra, Dothistroma pini,* provenances, growth, needles, disease resistance, windbreaks.

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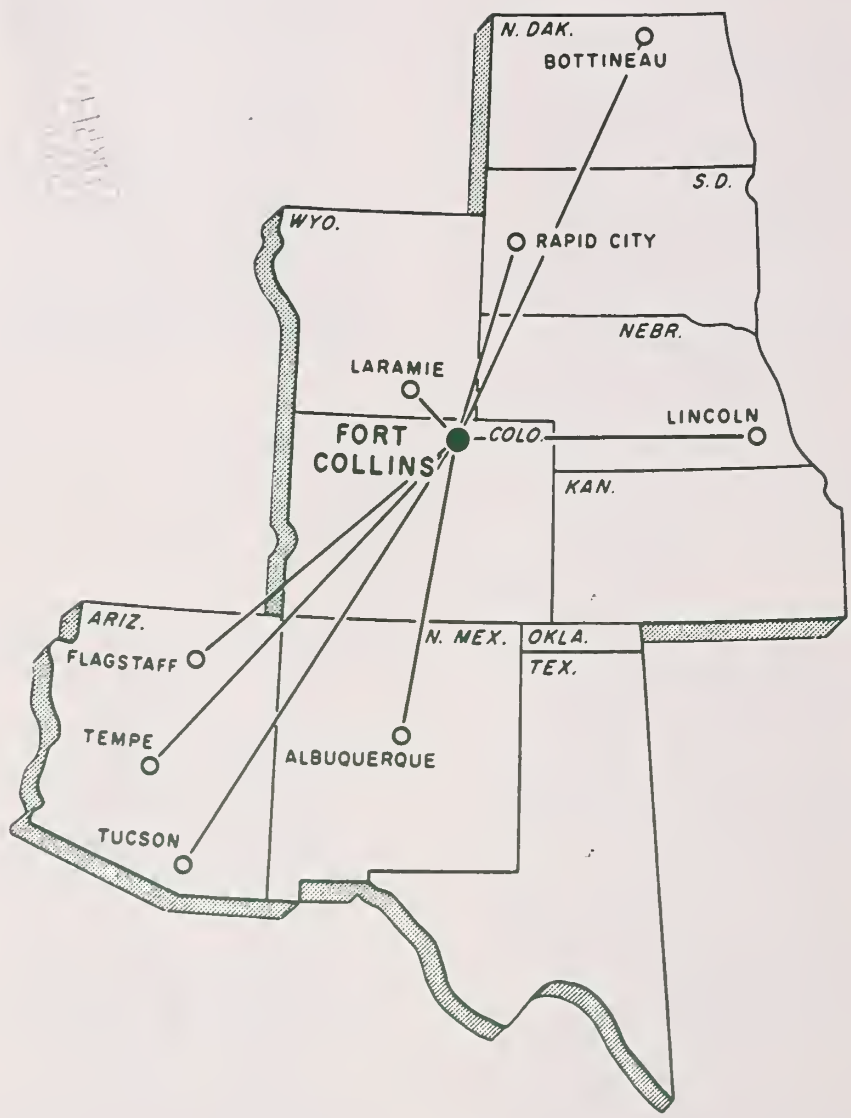
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